CHP
Combined Heat & Power
in Kentucky

Getting Started with CHP:
Initial Screening and Air Permitting

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CHP Partners

DEDI
KENTUCKY DEPARTMENT for ENERGY DEVELOPMENT & INDEPENDENCE

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KPPC
Kentucky's Resource Center for Environmental Sustainability

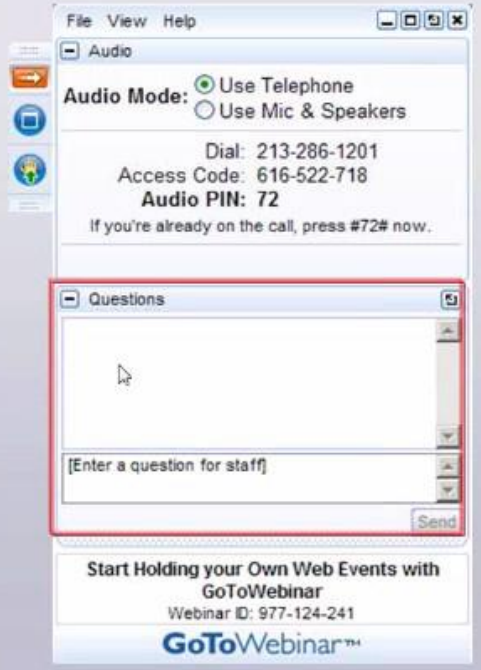
CHP

Before we start…

- **Today's webinar is being recorded and will be available at the KPPC website.**
- **All participants are muted to prevent feedback.**
- **We will be accepting questions through the question and answer portion of your control panel.**
- **Feel free to type questions as we present.**
- **We will address questions at the end of each presentation.**

More Housekeeping

How to Participate Today



- Open and close your Panel
- Submit text questions

CITRIX online

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Initial Screening for CHP

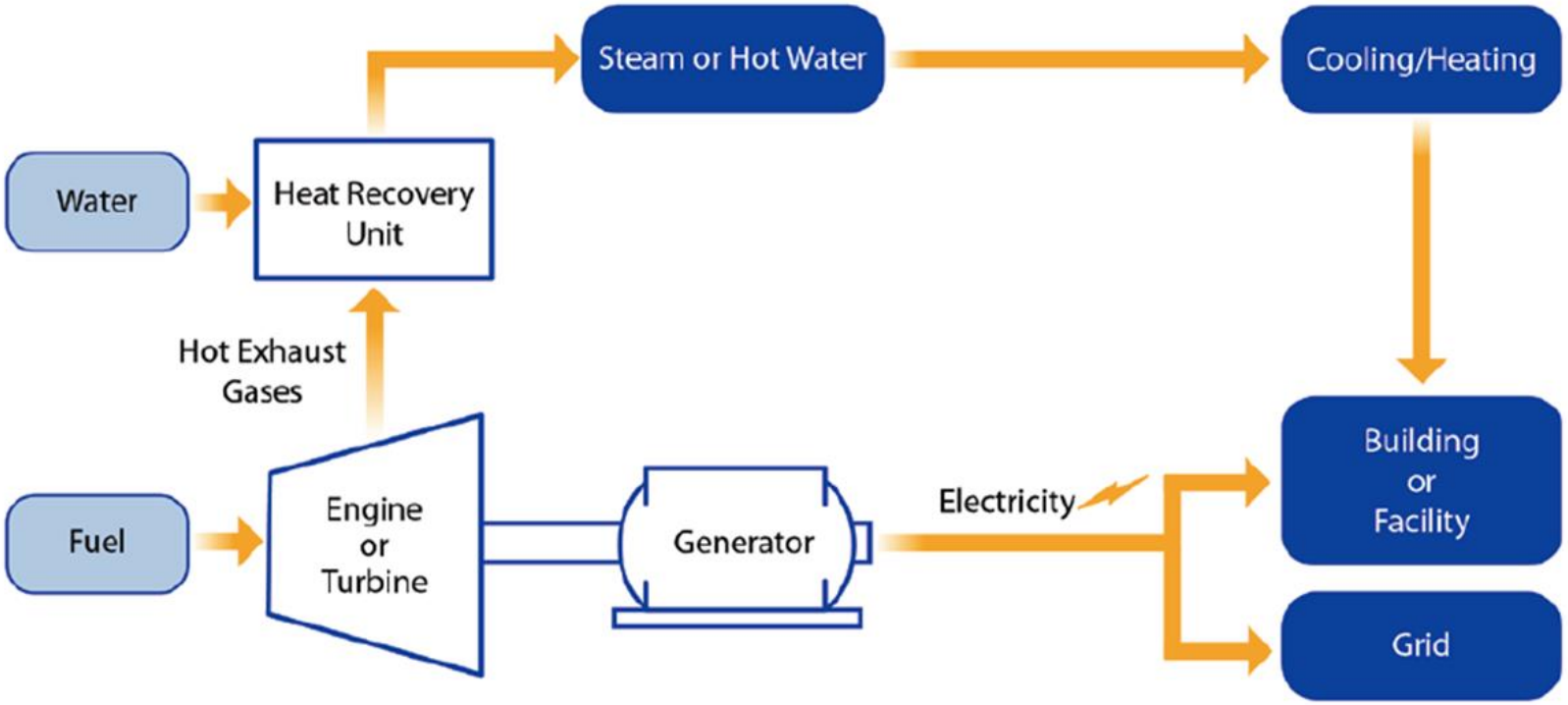
Cheryl Eakle, CEM
Sustainability Engineer
KPPC

What is Combined Heat and Power?

CHP is an *integrated energy system* that:

- Is located at or near a factory or building
- Generates electrical and/or mechanical power
- Recovers waste heat for
  - heating,
  - cooling or
  - dehumidification
- Can utilize a variety of technologies and fuels

Conventional CHP

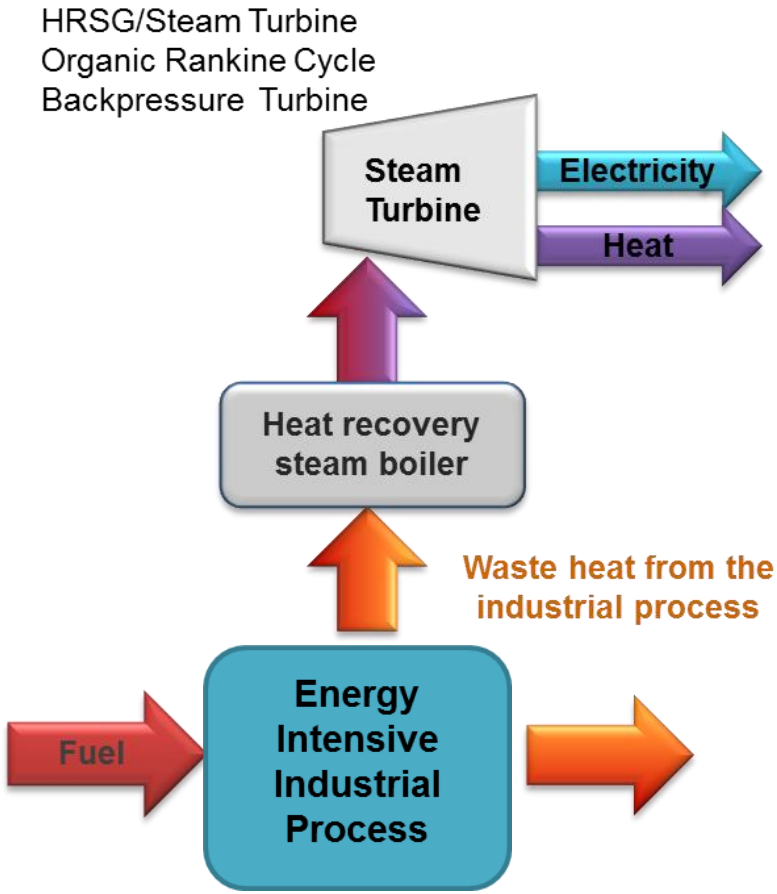


Separate Energy Delivery:

- **Electric generation – 33%**
- **Thermal generation - 80%**
- **Combined efficiency – 45% to 55%**

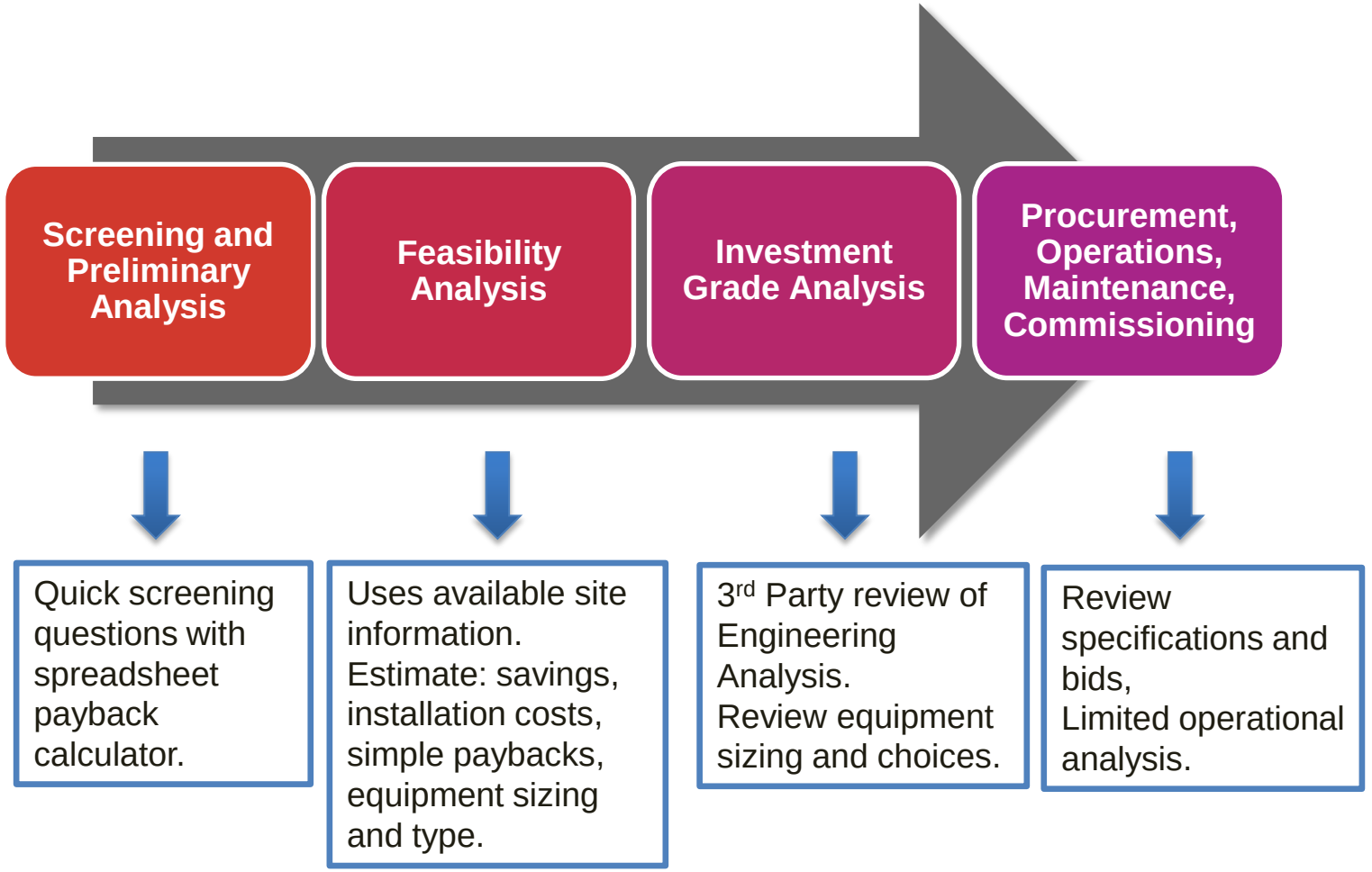
CHP Energy Efficiency (combined heat and power) 70% to 85%

Waste Heat to Power



- Fuel first applied to produce useful thermal energy for the process
- Waste heat is utilized to produce electricity and possibly additional thermal energy for the process
- Simultaneous generation of heat and electricity
- Normally produces larger amounts electric generation *(often exports electricity to the grid; base load electric power)*

CHP Project Development



CHP Initial Screening

CHP Combined Heat & Power in Kentucky

Kentucky CHP TAP Qualification Screening

Reciprocating Gas CHP System - no power export from site

Facility Information		
Facility Name	Hospital	
Location (City, State)	Somewhere, KY	
Application	In-Patient Care	
Annual Hours of Operation	8760	
Annual Electricity Consumption (kWh)	16,061,600	
Average Power Demand (MW)	1.83	
Annual Fuel Consumption (MMBtu)	53,953.00	
Annual Thermal Demand (MMBtu)	43,162.4	2012-2013 Actual Fuel Consumption times ~ 80% efficiency
Average Thermal Demand (MMBtu/hr)	4.9	
Average Electricity Costs ($/kWh)	$0.065	2012-2013 Average Electricity cost
Thermal Fuel Costs ($/MMBtu)	$5.030	2012-2013 Average Fuel cost
CHP Fuel Costs ($/MMBtu)	$5.030	
Percent Electric Price Avoided	80%	
CHP System		
Net CHP Power (MW)	1.20	
CHP Electric Efficiency, % (HHV)	38.0%	
CHP Thermal Output (Btu/kWh)	4,260	
CHP Power to Heat Ratio	0.80	Calculated based on CHP power output and thermal output
CHP Availability (%)	95%	90 to 98%
Incremental O&M Costs ($/kWh)	$0.010	
Displaced Thermal Efficiency (%)	80.0%	Displaced onsite thermal (boiler, heater, etc) efficiency
Thermal Utilization (%)	100.0%	Amount of available thermal captured and used - typically 80 to 100
Stand-by Electric Required? (1=Yes, 0=No)	0	
Required Standby Capacity (kW)		
Standby Charge ($/kW)		

Considerations--Electricity

- **Use base load if known (kW)**

- **Otherwise**

  $$\frac{\text{Annual electric use (kWh)}}{\text{Annual hours of operation}}$$

- **Use "effective" cost of electricity**

  $$\frac{\text{Annual electric cost (\$)}}{\text{Annual electric use (kWh)}}$$

- **Sub-meter information for partial facility**

Considerations--Thermal

- **Need year-round thermal demand**
- **Use base load if known (MMBtu/hr)**
- **Otherwise**

$$\frac{\text{Annual thermal load (MMBtu)}}{\text{Annual hours of operation}}$$

CHP Initial Screening

CHP Combined Heat & Power in Kentucky

CHP TAP CHP Qualification Screen

Boiler/Steam Turbine (backpressure) CHP

Facility Information

Facility Name	Auto Parts, Inc.	
Location (City, State)	Kentucky	
Application	Automotive Components	
Annual Hours of Operation	8400	Annual operating hours w
Average Power Demand, MW	6	6.8
Annual Electricity Consumption, kWh	57,000,000	
Average Steam Demand, MMBtu/hr	7.2	
Annual Steam Demand, MMBtu	60,480	
Current Fuel Costs, $/MMBtu	$5.79	
CHP Boiler Fuel Costs, $MM/Btu	$5.79	
Effective Electricity Costs, $/kWh	$0.077	
Percent Electric Price Avoided	90%	Typically 70 to 95%

CHP System

New Boiler = 1; Steam Turbine Only = 0	0	
CHP Availability, %	98%	Steam Turbine availabilit
Boiler Thermal Efficiency, %	80.0%	May need to modify for b
CHP Power to Heat Ratio	0.09	CHP System Specs 2 - use
Net CHP Power, MW	0.2	Based on typical power tc
CHP Electric Efficiency, % (HHV)	7.2%	Typically between 5 to 20
CHP Thermal Output, Btu/kWh	37,944	
Steam Turbine O&M Costs, $/kWh	$0.010	CHP system specs - incluc

CHP Initial Screening

Annual Energy Consumption

	Base Case	CHP Case
Generated Electricity, kWh	0	1,562,031
Purchased Electricty, kWh	57,000,000	55,437,969
Boiler Steam, MMBtu	60,480	0
CHP Boiler Steam, MMBtu	0	60,480
Boiler Fuel, MMBtu	75,600	0
CHP Boiler Fuel, MMBtu	0	82,398
Total Fuel, MMBtu	75,600	82,398

Stand-by Costs

Stand-by Power Needed (yes=1, no=0)	0
Stand-by Demand Required (kW)	
Stand-by Rate ($/kW)	
Administration Charge ($/month)	
Total Stand-by Costs ($)	$0.00

Annual Operating Costs

	Base Case	CHP Case
Purchased Electricity, $	$4,389,000	$4,280,751
Standby Power, $	$0	$0
On-site Thermal Fuel, $	$437,724	$0
CHP Fuel, $	$0	$477,085
Incremental O&M, $	$0	$15,620
Total Operating Costs, $	$4,826,724	$4,773,456

Simple Payback

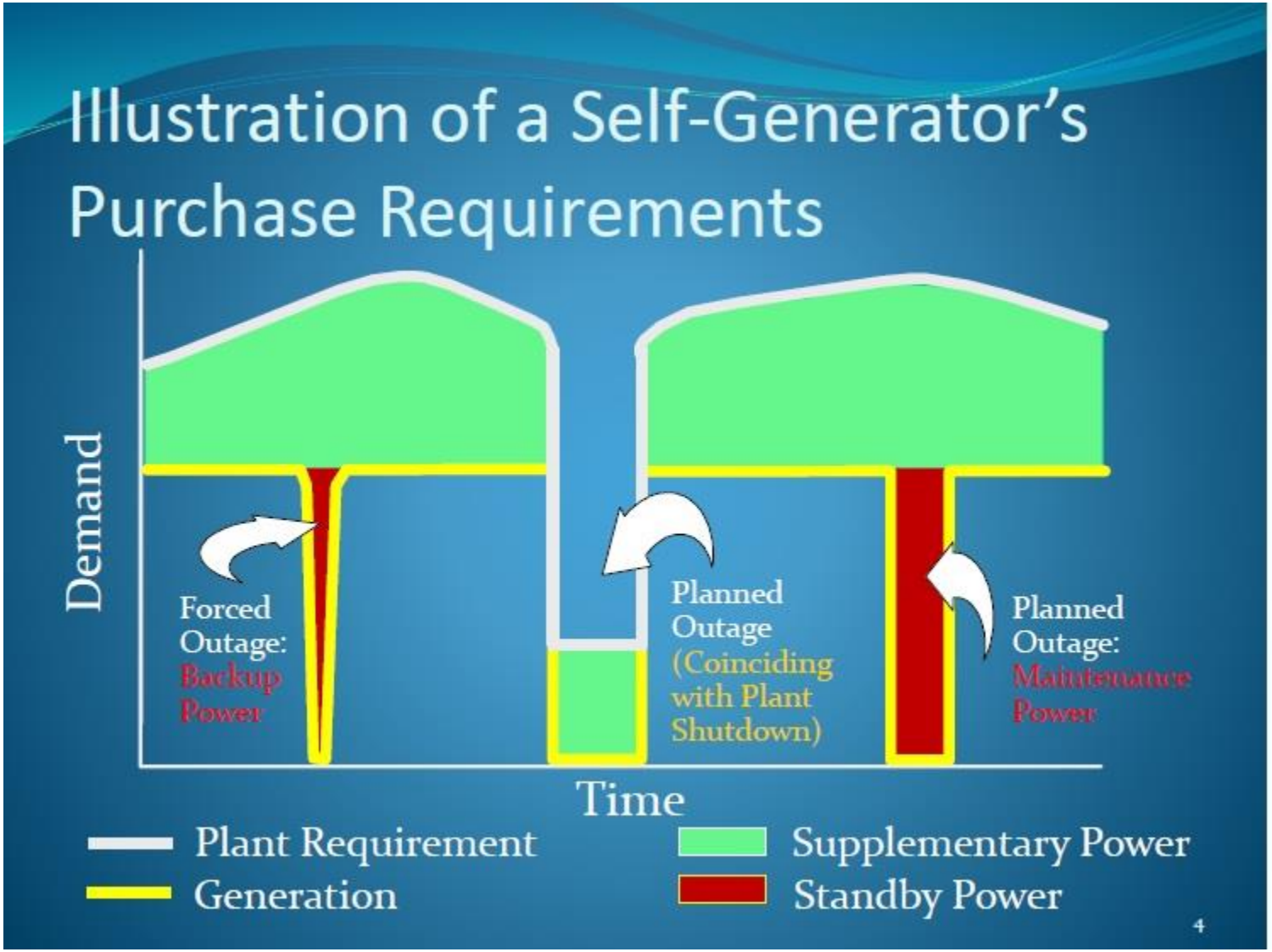
Annual Operating Savings, $	$53,268
Total Installed Costs, $/kW	$1,000
Total Installed Costs, $	$189,751
Simple Payback, Years	**3.6**

Operating Costs to Generate

Fuel Costs, $/kWh	$0.305
Thermal Credit, $/kWh	($0.280)
Incremental O&M, $/kWh	$0.010
Total Operating Costs to Generate, $/kWh	$0.035

Stand-by Rates

- **Stand-by rates can affect operating cost/savings**
- **Considerations**
  - Monthly charge or contract ($3.56-$12.86/kW)
  - Ratchet
  - Administrative charge
- **Work with utility**
- **Minimize stand-by charges**
  - Only use/contract for essential operations
  - Design system to shed loads for CHP outage
  - Use production shut-downs for maintenance



Courtesy of the Regulatory Assistance Project (RAP) and Brubaker and Associates

Conclusion

- **CHP is efficient use of energy**

- **Contact KPPC for free screening**
  - Need base loads (electric and thermal)
  - Effective costs (electric and fuel)
  - Consider stand-by costs

- **KPPC can do initial Feasibility Analysis (also at no cost)**

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QUESTIONS?

Initial Screening for CHP

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CHP
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Air Quality Permitting Requirements
for
CHP Processes

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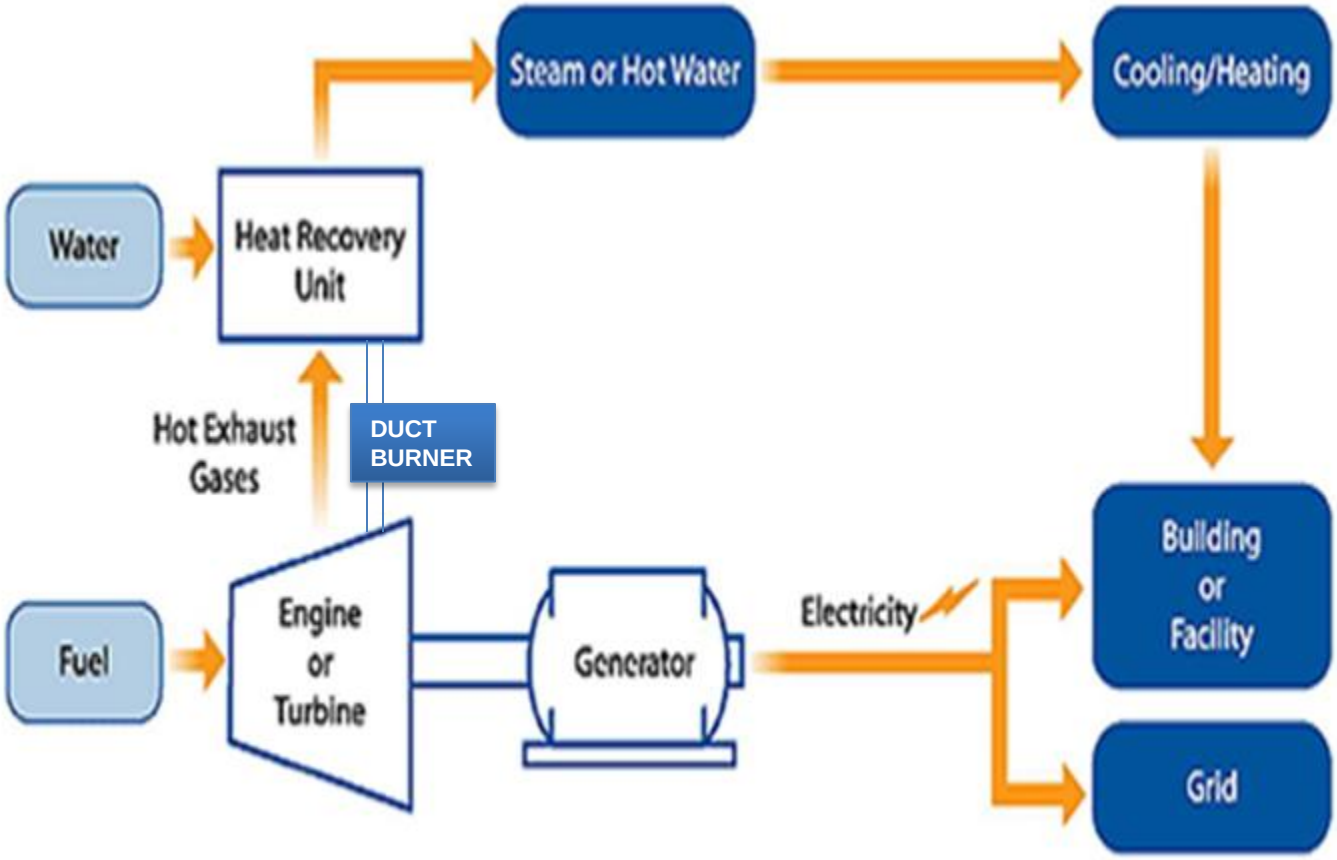
Kentucky Division for Air Quality

Typical CHP Process



Air Quality Permit to Construct and Operate

- **A Permit is a stand-alone document that includes regulatory requirements applicable to each of the sources emission units. In Kentucky the permit issued is a construction/operating permit that gives the source authority to construct and operate.**
- **The permit:**
- **identifies emission units to be regulated,**
- **establishes emission/operating limits to be met,**
- **outlines procedures including: Testing, Record keeping, Monitoring and Reporting requirements to maintain continuous compliance with the limits.**

Kentucky's Permitting/Registration Thresholds

- **Abbreviations:**
  - PTE means potential to emit, i.e., the maximum amount of a pollutant that a source is physically capable of emitting, or is legally allowed to emit, whichever is less
  - HAP means hazardous air pollutant
  - RAP means regulated air pollutant other than a HAP
  - AR means applicable requirement
  - MOC means method of compliance
  - NSPS means New Source Performance Standard
  - NESHAP means National Emission Standard for Hazardous Air Pollutants, and includes MACT/NESHAPS

When is a Permit Required?

- **<u>Construct and Operate</u> a new source**
  - Major source (Title V)
  - Synthetic minor source or Conditional Major source
    - Federal Enforceable State Operating Permit (FESOP)
  - Minor source
  - Registration only (small source)
- **<u>Modify</u> an existing source**
- **<u>Renew</u> an existing source**
- **"Source" means one (1) or more affected facilities contained within a given contiguous property line. "Affected facility" means an apparatus, building, operation, road, or other entity or series of entities that emits or may emit an air contaminant into the outdoor atmosphere.**

Kentucky's Permitting/Registration Thresholds

- **Nothing is required (no registration or permit) if a source's PTE is:**
  - <2 tpy of a HAP;
  - <5 tpy of combined HAPs;
  - <10 tpy of a RAP; and
  - The source is not subject to a NSPS or NESHAP
- **Registration is required if a source's PTE is:**
  - > 2 but < 10 tpy of a HAP
  - > 5 but < 25 of combined HAPs;
  - > 10 but < 25 tpy of a RAP subject to an AR that does not specify the MOC;
  - or
  - If the source is subject to a NSPS or NESHAP.

Kentucky's Permitting/Registration Thresholds

- **A state origin permit is required if a source's PTE is:**
  - < 10 tpy of a HAP;
  - < 25 tpy of combined HAPs; and
  - > 25 but <100 tpy of a RAP.
- **A Title V permit is required if a source's PTE is:**
  - > 10 tpy of a HAP;
  - > 25 tpy of combined HAPs; or
  - > 100 tpy of a RAP; and
  - The source's PTE is not limited below these thresholds by a permit (conditional major) or prohibitory rule.

Kentucky's Permitting – CHP Case Study

This case example is presented as a working exercise to facilitate discussion and is not intended to offer any formal or official interpretation of the Kentucky rules or federal rules.

PROJECT DESCRIPTION

- **XYZ campus (new under construction campus) is planning to construct CHP system to generate 10 MW of energy and 110,000 pounds of steam**
- **They found a natural gas turbine that can generate 8 MW of power and the Heat Recovery steam generator (HRSG) will produce 35000 pounds of steam. The turbine fuel input required is 80 mmBTU/hr.**
- **They decided to use this system with some changes to the CHP system and their plan.**
- **They decided to buy additional 2 MW they need from the grid.**
- **They decided to use 40 mmBTU/hr natural gas duct firing before the HRSG to give them additional 75,000 pounds of steam.**

Kentucky's Permitting – CHP Case Study

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AIR QUALITY PERMIT

- **To implement this plan an air permit from Kentucky Division for Air Quality (KDAQ) is needed.**
- **The source (permittee) needs the following data to submit an application to KDAQ**
  - 1. Engineering design of the affected units with information such as maximum design rate (units that generate air emissions).
  - 2. Emission Estimate for all the regulated air pollutants emitted from each affected unit within the source.
  - 3. Using emission estimates, figure out what kind of permit is required (use above thresholds given).
  - 4. What application forms and other documents need to be submitted?

Kentucky's Permitting – CHP Case Study

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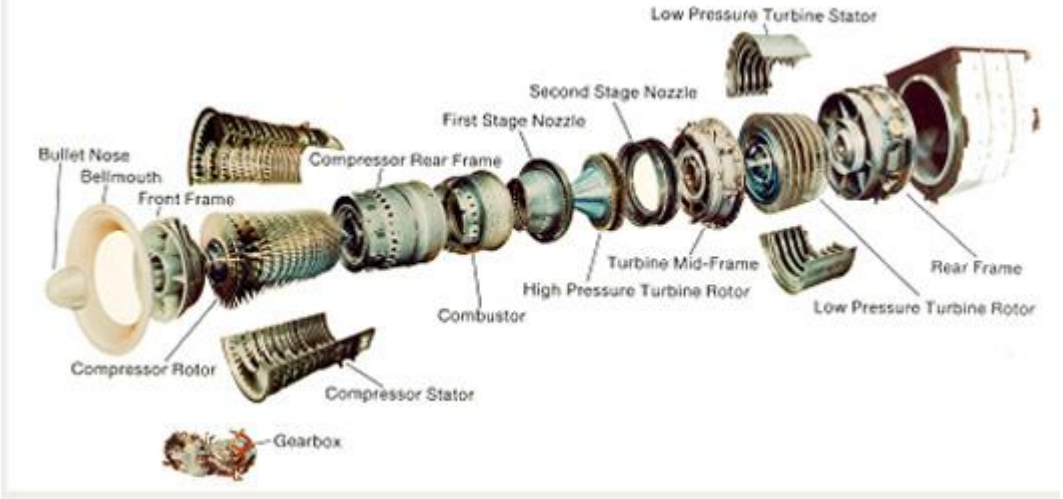
AIR QUALITY PERMIT – 1. Maximum Design Rate

- **Engineering design of the affected units (units that generate air emissions) will give information such as maximum design rate**

- **Engineering design includes data such as what is the maximum hourly raw material input needed for the equipment to work**
- **In this case study, Affected Units: 1. Turbine, 2. Duct Burner**
- **<u>Note</u>: the HRSG does not produce any air emissions. It recovers heat and produces steam. The units above are the only emission generating activities.**
- **<u>Maximum Design Rates</u>:**
- **1. Turbine → 80 mmBTU/hr fuel input (manufacturer's rating)**
- **2. Duct Burner → 40 mmBTU/hr fuel input (manufacturer's rating)**

Turbine – Setup

courtesy - Google images by www.interelectra.com and www.turbine-diesel.ru



Kentucky's Permitting – CHP Case Study

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AIR QUALITY PERMIT – 2. Emission Estimates

- Emissions shall be estimated for all the regulated air pollutants emitted from each affected unit within the source.
- The emissions estimates should be the "Potential emissions" for each affected unit.
- "Potential to emit" or "PTE" means the maximum capacity of a stationary source to emit a pollutant under its physical and operational design.
- PTE = Maximum hourly design rate X Emission factor X 8760 hr/yr
- For our case study, emission factors used are from manufacturer's data. There is also a compilation of emission factors at www.epa.gov/ttn/chief/ap42. When a unit is purchased the manufacturers generally provide emission guarantees. These emission factors can be used in PTE calculations, but Division has the authority to follow with Testing Requirements in the permit to verify these numbers.
- The hours per year used will always be 8760 hr/yr unless the source willingly takes permitted limits (called "voluntary limits"). If you want to take voluntary limits, you need to get a federally enforceable permit.
- For our case study we will estimate emissions for two different turbine configurations available with two different emission guarantees for NOx, CO and VOC. Better emission guarantee will be higher capital expenditure.

AIR QUALITY PERMIT – 2. Emission Estimates

TURBINE Emission Factors	Turbine 1			Turbine 2		
	NOx	CO	VOC	NOx	CO	VOC
lb/MMBtu	0.06	0.061	0.035	0.1	0.121	0.035
DUCT BURNER Emission Factors	**NOx**	**CO**	**VOC**	**NOx**	**CO**	**VOC**
lb/MMBtu	0.065	0.04	0.05	0.065	0.04	0.05
PTE in Tons per year	**NOx**	**CO**	**VOC**	**NOx**	**CO**	**VOC**
For TURBINE	21.02	21.37	12.26	35.04	42.4	12.26
For DUCT BURNER	11.39	7.01	8.76	11.39	7.01	8.76
TOTAL ANNUAL PTE	32.42	28.38	21.02	46.43	49.41	21.02

Kentucky's Permitting – CHP Case Study

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AIR QUALITY PERMIT – 3. WHAT PERMIT DO I NEED

- **Based on information from above slide, the source-wide emissions of all estimated regulated air pollutants (RAP) from this project are above 25 TPY but below 100 TPY.**
- **This will require a STATE ORIGIN PERMIT and will be regulated under 401 KAR 52:040, State Origin permits.**

Division for Air Quality
200 Fair Oaks Lane, 1st Floor
Frankfort, Kentucky 40601
(502) 564-3999

AIR QUALITY PERMIT
Issued under 401 KAR 52:040

Permittee Name:	XYZ Campus
Mailing Address:	123 Main Street, Suite 1, Hoginville, TX 32217
Source Name:	Frankfort Campus, Kentucky Division
Mailing Address:	1234 S. Brooke St. Frankfort, KY 40601
Source Location:	Corner of Brooke and Oak Streets
Permit:	S-15-973

Kentucky's Permitting – CHP Case Study

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AIR QUALITY PERMIT – 4. Application Forms and Other Documents

- Any construction activity emitting air pollution needs to get prior approval (permit, or Registration) from state of Kentucky. The application forms that need to be submitted will depend on if you need a permit or a registration.
- The application forms are listed on the Division website at www.air.ky.gov
- The forms are listed as a series starting from DEP7007A Form through DEP7007Y Form for permit related forms and DEP7039A form for a Minor source Registration applications.
- The form DEP7007AI form is the administrative information form listing the source information. Rest of the forms in the series require process, emissions, stack and compliance information from the source.
- DEP7007A form for example is the form for Indirect Heat Exchanger, Turbine, Internal Combustion Engine.
- For this project this would be one of the important forms to fill.

Kentucky's Permitting – CHP Case Study

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AIR QUALITY PERMIT – 4. Application Forms and Other Documents

- **The forms are mostly in Word format and are fillable. The forms generally followed by Instructions to fill.**

Program : Permitting (32)

CAIR Permit Application	CAIR Permit Application
DEP7007A Form	DEP7007A Indirect Heat Exchanger, Turbine, Interna Combustion Engine
DEP7007AA Form	DEP7007AA Compliance Schedule for Noncomplying Emission Units
DEP7007AA Instructions	DEP7007AA Compliance Schedule For Non-Complying Emission Units
DEP7007 AI Form	DEP7007AI Administrative Information
DEP7007B Instructions	DEP7007B Manufacturing and Processing Operations
DEP7007B Form	DEP7007B Manufacturing or Processing Operations

Kentucky's Permitting – CHP Case Study

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AIR QUALITY PERMIT – 4. Application Forms and Other Documents

- **The DEP 7007A form is used to list the details of the Turbine. See the DEP7007A form example below:**

2) **Type of Unit (Make, Model, Etc.):** Combustion Turbine (Caterpillar xyz) without Duct burner – Simple cycle operation

Date Installed: December 2014 (estimated) **Cost of Unit:** _____

(Date unit was installed, modified or reconstructed, whichever is later.)

Where more than one unit is present, identify with Company's identification or code for this unit:

Combustion Turbine (CT)) – Emission Point 1

2a) Kind of Unit (Check one):

5. **Indirect Heat Exchanger** _____
6. **Gas Turbine for Electricity Generation** X
7. **Pipe Line Compressor Engines:**
   - _____ **Gas Turbine**
   - _____ **Reciprocating engines**
     - (d) **2-cycle lean burn** _____
     - (e) **4-cycle lean burn** _____
     - (f) **4-cycle rich burn** _____
8. **Industrial Engine** _____

2b) Rated Capacity: (Refer to manufacture's specifications)

1. **Fuel input (mmBTU/hr):** NG: 80 (HHV) @ 59 deg Fahrenheit
2. **Power output (hp):** _____

Power output (MW): NG: 8 MW @ 59 deg Fahrenheit [1]

[1] Plant Gross Generation

SECTION I. FUEL

3) **Type of Primary Fuel** *(Check)*:

_____ A. Coal _____ B. Fuel Oil: *# (Check one)* ___ 1 ___ 2 ___ 3 ___ 4 ___ 5 ___ 6

X C. Natural Gas _____ D. Propane _____ E. Butane _____ F. Wood _____ G. Gasoline

_____ H. Diesel _____ I. Other *(specify)* _____

4) **Secondary Fuel** *(if any, specify type)*: _____

Kentucky's Permitting – CHP Case Study

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AIR QUALITY PERMIT – 4. Application Forms and Other Documents

- **The DEP7007V form is used to list the applicable requirements and compliance activities. See the example below:**

SECTION I. EMISSION AND OPERATING STANDARD(S) AND LIMITATION(S)

KYEIS No.[1]	Emission Unit Description[2]	Contaminant[3]	Origin of Requirement or Standard[4]	Applicable Requirement, Standard, Restriction, Limitation, or Exemption[5]	Method of Determining Compliance with the Emission and Operating Requirement(s)[6]
098 099 100	Combustion Turbine - Simple Cycle	NOX	40 CFR 60 Subpart KKKK	Natural Gas Emission Limit: 15 ppm at 15 percent O2	Vendor guarantees meet these limits.
		SO2	40 CFR 60 Subpart KKKK	Fuel Emission Limit: 0.06 lb SO2 / 10^6 Btu	Fuel analysis indicates 0.06 lb SO2 / 10^6 Btu will not be exceeded

SECTION II. MONITORING REQUIREMENTS

KYEIS No.[1]	Emission Unit Description[2]	Contaminant[3]	Origin of Requirement or Standard[4]	Parameter Monitored[7]	Description of Monitoring[8]
098 099 100	Combustion Turbine - Simple Cycle	NOX	40 CFR 60 Subpart KKKK	NOX	Continuous Emissions Monitoring System for each combustion turbine

SECTION III. RECORDKEEPING REQUIREMENTS

KYEIS No.[1]	Emission Unit Description[2]	Contaminant[3]	Origin of Requirement or Standard[4]	Parameter Recorded[9]	Description of Recordkeeping[10]
098 099 100	Combustion Turbine - Simple Cycle	N/A	40 CFR 60.7(b)	Start-ups, shutdowns, and malfunctions	Maintain records of these events.

Sample sheet only. Not related to the example project above.

SECTION IV. REPORTING REQUIREMENTS

KYEIS No.[1]	Emission Unit Description[2]	Contaminant[3]	Origin of Requirement or Standard[4]	Parameter Reported[11]	Description of Reporting[12]
098 099 100	Combustion Turbine - Simple Cycle	N/A	40 CFR 60 Subpart KKKK	See Table 3-2 of main document for requirements	
			40 CFR 63 Subpart YYYY	See Table 3-7 of main document for requirements	

SECTION V. TESTING REQUIREMENTS

KYEIS No.[1]	Emission Unit Description[2]	Contaminant[3]	Origin of Requirement or Standard[4]	Parameter Tested[13]	Description of Testing[14]
098 099 100	Combustion Turbine - Simple Cycle	CO, NOX, SO2	40 CFR 60.8(a)	Performance test of combustion turbines	Performance testing must occur within 60 days after achieving maximum production rate but no later than 180 days after initial start-up.

Kentucky's Permitting – CHP Case Study

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AIR QUALITY PERMIT – 4. Application Forms and Other Documents

- **The permittee can contact the Division for assistance on the forms or any other permit related questions. See the contact information on Division's website.**
- **The DEP7007N form is used to submit the emissions and stack information. See an example below:**

SECTION I. Emission Units and Emission Point Information (continued)

KyEIS ID #	Emission Factors			Control Equipment		Hourly (lb/CT-hr) Emissions			Annual (tons/CT-yr) Emissic		
	Pollutant	Emission Factor (lb/SCC Units)	Emission Factor Basis	Control Equipment Association	Pollutant Overall Efficiency (%)	Uncontrolled Unlimited Potential	Controlled Limited Potential	Allowable	Uncontrolled Unlimited Potential	Controlled Limited Potential	Allow
101	Filter. PM	4.03E-03	Vendor Data	1st control device	Low-NOX		9.00	9.00		39.4	18.6
or	Filter. PM10	4.03E-03	AP-42, Ch. 3.2	KyEIS Control ID #:	01		9.00	9.00		39.4	18.6
102	Filter. PM2.5	4.03E-03	AP-42, Ch. 3.2	Collection efficiency:			9.00	9.00		39.4	18.6
or	Cond. PM	4.03E-03	Eng. Estimate				9.00	9.00		39.4	18.6
103	SO2	1.92E-03	Eng. Estimate	2nd control device	CatOx*		4.28	4.28		18.7	8.83
	NOX	7.23E-03	Vendor Data	KyEIS Control ID #:	02	90%	161	16.1		706	33.3
	CO	5.50E-03	Vendor Data	Collection efficiency:		70%	40.9	12.3		179	25.3
	VOC	1.89E-03	Vendor Data			30%	6.02	4.22		26.4	8.71
	H2SO4	1.71E-05	Eng. Estimate	3rd control device	SCR		0.0382	0.0382		0.167	0.0788
	CO2 equiv.	1.17E+02	40 CFR Part 98	KyEIS Control ID #:	03		261,246	261,246		1,144,257	539,473
	Lead	4.00E-07	EPRI's EFH*	Collection efficiency:	70%		8.92E-04	8.92E-04		3.91E-03	1.84E-03
	Total HAP	4.57E-04	AP-42 & EFH**				1.020	1.020		4.47	2.11

Sample sheet only. Not related to the example project above.

CHP
Combined Heat & Power
in Kentucky

QUESTIONS?

Air Quality Permitting Requirements
for
CHP Processes

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Resources

- **KPPC**
  www.kppc.org
- **Division for Air Quality**
  www.air.ky.gov
- **DEDI**
  http://energy.ky.gov/Programs/Pages/chp.aspx
- **DOE**
  www.doe.gov or www.energy.gov
- **Southeast CHP Technical Assistance Partnership**
  www.southeastchptap.org/

CHP

Resources

- **Association of Energy Engineers**
  www.aeecenter.org

- 

  www.energystar.gov/

Wrap-Up

- **Webinar Recording**

  www.kppc.org

- **Upcoming Event**
  - Site Visit & Demonstration – March 2015

- **Webinar Survey**

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